

# **Understanding Insulation Materials Options for Busbars**

**Applications** Note

Choosing insulation materials for busbars involves considering several tradeoffs based on their specific properties and applications. Selecting the right insulation materials that meet all requirements is a crucial factor for the success of an electrical system for several reasons:

- Electrical Safety and Performance: Insulation materials provide electrical isolation between the conductors and the surrounding environment. This prevents short circuits, reduces leakage currents, and ensures the system operates safely at the required voltages. Using subpar insulation can lead to electrical faults, power outages, or potential hazards, undermining the integrity of the system.
- **Mechanical Durability:** The right insulation material must also contribute to the mechanical strength of the busbar system. In environments with high vibrations or physical stress, the insulation must be robust enough to protect against wear and tear. Poorly chosen insulation may degrade faster under mechanical stresses, leading to premature failure of the busbar system.
- Compliance with Standards: Electrical systems, especially in industries such as automotive, aerospace, and industrial manufacturing, must adhere to strict safety and regulatory standards. Insulation materials need to meet these industry requirements for temperature, dielectric strength, and chemical resistance. Choosing the right insulation material ensures compliance with these standards and avoids costly penalties or redesigns.
- Longevity and Reliability: Over time, insulation can degrade due to environmental factors such as moisture, chemicals, and high temperatures. The correct insulation material will help increase the lifespan of the busbar system, ensuring that it operates reliably for many years without requiring frequent repairs or replacements. Long-lasting insulation is a cost-effective solution over the long term.
- Cost-Effectiveness: While high-performance insulation materials like Nomex or Kapton may have a higher upfront cost, choosing inadequate material for the design, can lead to costly failures, repairs, and downtime. By selecting the correct material upfront, companies can avoid expensive mistakes and operational disruptions, making it more cost-effective in the long run.
- Energy Efficiency: Optimizing insulation helps enhance overall energy efficiency, ensuring that the electrical system runs smoothly without unnecessary waste, which is especially important in systems aiming for high efficiency, such as those used in electric vehicles or power distribution networks
- Environmental Impact: As industries move toward more sustainable practices, choosing insulation materials that are environmentally friendly, recyclable, and have low ecological footprints is becoming increasingly important. The right insulation can minimize the environmental impact of busbar production and disposal, helping meet green energy or sustainability goals.
- **Cosmetic Requirements:** Insulation can satisfy cosmetic requirements for high visibility parts. Insulation materials come in many colors.
- Human Safety: In addition to lock out / tag out procedures, insulating bus bars can add an additional layer of saftey. Electrical insulation is crucial for human safety by preventing electric shock and fire hazards. It isolates energized parts from accidental contact, minimizing the risk of electrocution and damage to equipment.

## Applications Note: Understanding Insulation Materials Options for Busbars

Choosing insulation materials for busbars involves considering several tradeoffs based on their specific properties and applications. Here are the key tradeoffs for common insulation films used in busbars like PET (Polyethylene Terephthalate), Nomex, Kapton, and PEN (Polyethylene Naphthalate), or in some situations Epoxy Powder Coat may be applicable.

Below we look at the key parameters that should be taken into account when making your selection.



Thermal Performance: continuous use temperature range in which material will not experience degradation

- PET can handle temperatures up to 105 C° and PEN is rated up to 125 C°.
- Epoxy Powder Coat is rated from 130 C° to 180 C° depending on type.
- Nomex 410 can deliver performance from 180 C° to 220 C°, depending on the adhesive.
- Kapton can be used for thermal environments from 200 C° to 240 C° with the ability to deliver higher performance in some specialized applications.

Electrical Insulation Properties: ATSM dielectric strength per mil of thickness (V/mil)

- Nomex 410 insulation rating is generally under 1000 V/mil
- Kapton is rated at 3000-5000 V/mil
- PET is rated from 2700-5000 V/mil
- Epoxy Powder Coating is rated at 800-1200 V/mil and can be readily applied in various thicknesses to accommodate a complex range of geometries

### Mechanical Strength and Flexibility:

- PEN and PET are both very easy to handle and provides ample flexibility for bending and molding
- Nomex 410 is durable but is not very flexible and can require gentle handling
- Kapton is tough but lacks the flexibility of PEN or PET
- Epoxy coating conforms to geometry during application

#### **Chemical Compatibility:**

- All options are generally resistant to chemicals but may degrade in harsh chemical environments
- All are hydroscopic to varying degrees but Nomex 410 is most susceptible to absorbing moisture so consideration should be given when working with it in high humidity environments.

#### Cost and Availability:

- PET: Generally cost-effective and widely available.
- PEN: Typically more expensive than PET but offers superior thermal and electrical performance.
- Nomex and Kapton: More expensive compared to PET but offer superior performance in high-temperature and high-voltage applications.
- Epoxy Coating: Less expensive from materials standpoint but more expensive for labor to apply.

#### Summary

In summary, selecting the right insulation material for busbars is critical for ensuring the system's safety, reliability, and efficiency. The right choice mitigates risks, extends the life of the system, reduces costs, and meets regulatory requirements, which are all essential for long-term success in any electrical application.

The table below provides a summary of key ratings and characteristics of the various options.

Material	Continuous Use Temp C°	Dielectric Strength ASTM D149	Flammability Rating	Characteristics
		(Volts/ml)		
PET	105 C°	2700-5000 V/mil	UL 94 VTM-0	Cost effective,tear, chemical,and moisture resistant
PEN	125 C°	2700-5000 V/mil	UL 94 VTM-0	Higher deflective strength & continuous use temp
Nomex	180 C°- 220 C°	under 1000 V/mil	UL 94 V-0	Flame resistant, durable
Kapton	200 C° - 240 C°	3000-5000 V/mil	UL 94 VTM-0	High temp rating & range stability
Epoxy Powder Coating	130 C° - 180 C°	800-1200 V/mil	UL 94 V-0	Flame, moisture resistant; ideal for multiple shapes

At Storm Power Components, our engineering teams have decades of experience with designing complex busbars that have proven reliable in the most demanding of deployments. This is because we always start with the end goal of the system in mind and then bring our knowledge, experience, and creativity together in a holistic manner to achieve those goals.

This is particularly important when making key decisions between alternatives for insulation materials and design, which are critical elements for success with creating busbars that meet each application's specific operating requirements and lifecycle projections.

